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PATENT APPLICATION

for

FLYWHEEL ASSEMBLY

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FLYWHEEL ASSEMBLY

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a flywheel assembly. More specifically, the present invention relates to a flywheel assembly, in which a flywheel is connected to a crankshaft through a damper mechanism.

2. Background Information

Conventionally, a flywheel is attached to a crankshaft of an engine for absorbing vibrations caused by variations in engine combustion. Further, a clutch device is arranged on a transmission side (i.e., in a position axially shifted toward the transmission) with respect to the flywheel. The clutch device usually includes a clutch disk assembly coupled to an input shaft of the transmission and a clutch cover assembly for biasing the frictional coupling portion of the clutch disk assembly toward the flywheel. The clutch disk assembly typically has a damper mechanism for absorbing and damping torsional vibrations. The damper mechanism has elastic members such as coil springs arranged for compression in a rotating direction.

A structure is also known in which the damper mechanism is not arranged in the clutch disk assembly, and rather is arranged between the flywheel and the crankshaft. In this structure, the flywheel is located on the output side of a vibrating system, in which the coil springs form a border between the output and input sides, so that an inertia on the output side is larger than that in other prior art. Consequently, the resonance rotation speed can be lower than an idling rotation speed so that damping performance is improved. The structure, in which the flywheel and the damper mechanism are combined as described above, provides a flywheel assembly and/or a flywheel damper.

In a conventional flywheel assembly, a disk-like plate called "a flexible plate" is used to connect the flywheel to the crankshaft so that it is possible to decrease bending vibrations from the crankshaft. The flexible plate has a high rigidity in the rotating direction to transmit torque, but it has a low rigidity in the bending direction to bend in response to bending vibrations, as shown in Unexamined Japanese Patent Publication H10-231897, which is hereby incorporated by reference.

When a flexible plate is used to connect a flywheel to a crankshaft, the radially inward portion of the flexible plate is usually fixed to the crankshaft through a plurality of bolts. Further, the radially outward portion of the flexible plate is usually fixed to the flywheel through a plurality of bolts. In a modular clutch, in which the clutch device and the flywheel are composed as a module, a complex structure for bolts fixing the flexible plate to the crankshaft is formed.

In a conventional flywheel assembly, the damper mechanism preferably includes a low rigidity damper and a high rigidity damper. The low rigidity damper only operates in a region where torque is small and the high rigidity damper operates in a region where torque is large. Generally, the low rigidity damper and the high rigidity damper are located such that ends of both dampers exert a load on each other, i.e., they are located in series in the rotating direction in a torque transmission system. In the flywheel assembly, the low rigidity damper is attached to a crankshaft side member, and the high rigidity damper is attached to the flywheel side member.

In a conventional flywheel assembly, however, the structure for attaching the low rigidity damper to the crankshaft side member is complicated and it is impractical to assemble the flywheel assembly. In view of the above, there exists a need for

flywheel assembly that overcomes the above-mentioned problems in the prior art. This invention addresses this need in the prior art as well as other needs, which will become apparent to those skilled in the art from this disclosure.

SUMMARY OF THE INVENTION

An object of the present invention is to simplify attaching and detaching a flywheel to and from a support member for supporting the flywheel on the crankshaft.

An alternate object of the present invention is to simplify attaching and detaching a flywheel to and from a torque transmitting member for transmitting torque to the flywheel.

Still another object of the invention is to simplify attaching and detaching a flywheel to and from a flexible member to support flexibly the flywheel in the bending direction.

Still another object of the invention is to simplify the to simplify the assembly of a low rigidity damper to the crankshaft in a flywheel assembly having a damper mechanism, which has the low rigidity damper and a high rigidity damper. According to a first aspect of the present invention, a flywheel assembly to which torque is transmitted from a crankshaft of an engine includes a flywheel, a damper mechanism, and a support member. The damper mechanism elastically connects the flywheel to the crankshaft in a rotating direction. The support member is attached to the crankshaft and supports the flywheel on the crankshaft. The support member has an axially extending portion attachable to and detachable from the flywheel in the axial direction.

In this flywheel assembly, when the crankshaft rotates, torque is transmitted to the damper mechanism, and further to the flywheel. When torque variation due to

combustion fluctuation of the engine is inputted to the flywheel assembly, the damper mechanism operates to absorb torsional vibrations. In this flywheel assembly, it is easy to assemble and disassemble the flywheel and the support member because the axially extending portion is attachable to and detachable from the flywheel in the axial direction.

A flywheel assembly in accordance with a second aspect of the present invention is the flywheel assembly of the first aspect, wherein the support member supports the flywheel in the axial direction. In this flywheel assembly, the support member has a function of supporting the flywheel in the axial direction.

A flywheel assembly in accordance with a third aspect of the present invention is the flywheel assembly of the second aspect, wherein the support member supports the flywheel in the radial direction. In this flywheel assembly, the support member has a function of supporting the flywheel in the radial direction.

A flywheel assembly in accordance with a fourth aspect of the present invention is the flywheel assembly of any of the previous aspects, wherein the support member is flexible in the bending or axial direction and supports the flywheel such that the flywheel can move in the bending direction. In this flywheel assembly, the support member has a function of supporting the flywheel in the bending direction such that the flywheel can move in the bending direction.

A flywheel assembly in accordance with a fifth aspect of the present invention is the flywheel assembly of any of the previous aspects, wherein the support member supports the flywheel through the damper mechanism.

A flywheel assembly in accordance with a sixth aspect of the present invention is the flywheel assembly of any of the previous aspects, wherein the support member

transmits torque to the damper mechanism. In this flywheel assembly, the support member has a function of transmitting toque.

A flywheel assembly in accordance with a seventh aspect of the present invention is the flywheel assembly of any of the previous aspects, wherein the support member has a plurality of axially extending portions extending axially and arranged in the rotating direction. The rigidity of the support member is lower than that of conventional support members because the support member has a plurality of axially extending portions.

A flywheel assembly in accordance with an eighth aspect of the present invention is the flywheel assembly of the seventh aspect, wherein the support member is composed of an annular portion fixed to the crankshaft and a plurality of radially outward extending portions. The plurality of axially extending portions extends axially from the radially outward extending portions. In this flywheel assembly, the support member is made of a single simple structure.

A flywheel assembly in accordance with a ninth aspect of the present invention is the flywheel assembly of the eighth aspect, wherein an axial gap is secured between the radially outward portions and a crankshaft side member. In this flywheel assembly, the radially outward portions can deform to approach the crankshaft side member.

According to a tenth aspect of the present invention, a flywheel assembly to which torque is transmitted from a crankshaft of an engine includes a flywheel, a damper mechanism, and a torque transmission member. The damper mechanism elastically connects the flywheel to the crankshaft in a rotating direction. The torque transmission member is attached to the crankshaft and transmits torque to the damper

mechanism. The torque transmission member has axially extending portions attachable to and detachable from the damper mechanism in the axial direction.

In this flywheel assembly, when the crankshaft rotates, torque is transmitted to the damper mechanism, and further to the flywheel. When torque variation due to combustion fluctuation of the engine is inputted to the flywheel assembly, the damper mechanism operates to absorb torsional vibrations. In this flywheel assembly, it easy to assemble and disassemble the damper mechanism and the torque transmission member because the axially extending portion is attachable to and detachable from the damper mechanism in the axial direction.

A flywheel assembly in accordance with an eleventh aspect of the present invention is the assembly of the tenth aspect, wherein the damper mechanism includes a first damper having a first spring to realize low rigidity characteristics in a small torsional angle area of torsional characteristics and a second damper having a second spring to realize high rigidity characteristics in a large torsional angle area of the torsional characteristics. The first damper includes the first spring, a first member to supports rotating direction ends of the first spring, and a second member that is relatively rotatable to the first member and supports the rotating direction ends of the first spring. The axially extending portions are engaged with the first member in the rotating direction. In this flywheel assembly, torque is transmitted through the first member, the first spring, and the second member in this order in the first damper. When the first member and the second member rotate relatively, the first spring is compressed between the first and second members.

A flywheel assembly in accordance with a twelfth aspect of the present invention is the assembly of the eleventh aspect, wherein the first member is formed with a plurality of first axially penetrating holes. Further, the axially extending

portions extend through the first axially penetrating holes. In this flywheel assembly, the axially extending portion can directly transmit torque to the first member and can be attached to and detached from the first member in the axial direction.

A flywheel assembly in accordance with a thirteenth aspect of the present invention is the assembly of the twelfth aspect, wherein the second member is formed with a plurality of second axially penetrating holes corresponding to the first axially penetrating holes. The second axially penetrating holes are longer in the rotating direction than the first axially penetrating holes and the axially extending portions. The axially extending portions extend through the second axially penetrating holes in the axial direction. In this flywheel assembly, an axially extending portion can move in its respective second axially penetrating hole in the rotating direction.

A flywheel assembly in accordance with a fourteenth aspect of the present invention is the assembly of the thirteenth aspect, wherein the second member has a shape of block. The first member is a plate having at least a portion located on one of axial sides of the second member. In this flywheel assembly, the first member and the second member have simple structures.

A flywheel assembly in accordance with a fifteenth aspect of the present invention is the assembly of any one of the eleventh to fourteenth aspects, wherein the first spring is held by the first member and the second member such that the first spring is not separated from the first member and the second member.

A flywheel assembly in accordance with a sixteenth aspect of the present invention is the assembly of any one of the eleventh to fifteenth aspects, wherein there is a plurality of second springs. The second springs are arranged in the rotating direction. Further, there is a plurality of first dampers. The first dampers are located between the second springs in the rotating direction. In this flywheel assembly, radial

size of the damper mechanism does not become excessively large, because the first dampers are located between the second springs in the rotating direction.

A flywheel assembly in accordance with a seventeenth aspect of the present invention is the flywheel assembly of the sixteenth aspect, wherein the first springs are completely disposed within an annular area defined by a radially inward edge and a radially outward edge of the second springs. In this flywheel assembly, radial size of the damper mechanism is not excessively large because the first springs are completely disposed within the annular area

A flywheel assembly in accordance with an eighteenth aspect of the present invention is the flywheel assembly any one of the eleventh to seventeenth aspects, wherein the second member is engaged with rotating direction ends of the second spring such that the second member and the second spring can transmit torque therebetween. In this flywheel assembly, torque is transmitted from the second member to the second spring.

A flywheel assembly in accordance with a nineteenth aspect of the present invention is the flywheel assembly any one of the tenth to eighteenth aspects, wherein the torque transmission member is flexible in the bending direction and supports the flywheel such that the flywheel can move in the bending direction. In the flywheel assembly, the torque transmission member has a function of supporting the flywheel such that the flywheel can move in the bending direction, as well as a function of transmitting torque to the flywheel.

A flywheel assembly in accordance with a twentieth aspect of the present invention is the flywheel assembly any one of the tenth to nineteenth aspects, wherein the axially extending portions are arranged in the rotating direction. The rigidity of

the torque transmission member is lower than in conventional assemblies because the torque transmission member has a plurality of axially extending portions.

A flywheel assembly in accordance with a twenty-first aspect of the present invention is the flywheel assembly of the twentieth aspect, wherein the torque transmission member is composed of an annular portion fixed to the crankshaft and a plurality of radially outward extending portions. The plurality of radially outward extending portions extends from the annular portion. Further, the plurality of axially extending portions extends from the radially outward extending portions. In this flywheel assembly, the torque trasmission member is made of a single simple structure.

A flywheel assembly in accordance with a twenty-second aspect of the present invention is the flywheel assembly of the twenty-first aspect, wherein an axial gap is secured between the radially outward portions and a crankshaft side member. In this flywheel assembly, the radially outward portions can deform to approach the crankshaft side member.

According to a twenty-third aspect of the present invention, a flywheel assembly to which torque is transmitted from a crankshaft of an engine includes a flywheel, a damper mechanism, and a flexible member. The damper mechanism elastically connects the flywheel to the crankshaft in a rotating direction. The flexible member is flexible in the bending direction and supports the flywheel on the crankshaft such that the flywheel can move in the bending direction. The flexible member has an axially extending portion attachable to and detachable from the flywheel in the axial direction.

In this flywheel assembly, when the crankshaft rotates, torque is transmitted to the damper mechanism, and further to the flywheel. When torque variation due to

combustion fluctuation of the engine is inputted to the flywheel assembly, the damper mechanism operates to absorb torsional vibrations. When bending vibrations are inputted from the engine to the flywheel assembly, the flexible member elastically deforms in the bending direction to absorb the bending vibrations. In this flywheel assembly, it is easy to assemble and disassemble the flywheel and the flexible member because the axially extending portion is attachable to and detachable from the flywheel in the axial direction.

A flywheel assembly in accordance with a twenty-fourth aspect of the present invention is the flywheel assembly of the twenty-third aspect, wherein the flexible member has a plurality of axially extending portions arranged in the rotating direction. The rigidity of the flexible member is lower than conventional flexible members because the flexible member has a plurality of axially extending portions.

A flywheel assembly in accordance with a twenty-fifth aspect of the present invention is the flywheel assembly of the twenty-fourth aspect, wherein the flexible member is composed of an annular portion fixed to the crankshaft and a plurality of radially outward extending portions extending from the annular portion. Further, the plurality of axially extending portions extends from the radially outward extending portions. In this flywheel assembly, the flexible member is made of a single simple structure.

A flywheel assembly in accordance with a twenty-sixth aspect of the present invention is the flywheel assembly of the twenty-fifth aspect, wherein an axial gap is secured between the radially outward portions and a crankshaft side member. In this flywheel assembly, the radially outward portions can deform to approach the crankshaft side member.

A flywheel assembly in accordance with a twenty-seventh aspect of the present invention is the flywheel assembly of any one of the twenty-third to twenty-sixth aspects, wherein the flexible member supports the flywheel through the damper mechanism.

A flywheel assembly in accordance with a twenty-eighth aspect of the present invention is the flywheel assembly of the any one of the twenty-third to twenty-seventh aspects, wherein the axially extending portions function as torque input portions to the damper mechanism. In this flywheel assembly, the flexible member has a function of a torque transmission and a function of bending vibration absorption.

A flywheel assembly in accordance with a twenty-ninth aspect of the present invention is the flywheel assembly of the twenty-eighth aspect, wherein the damper mechanism includes a first damper having a first spring to realize low rigidity characteristics in a small torsional angle area of torsional characteristics and a second damper having a second spring to realize high rigidity characteristics in a large torsional angle area of the torsional characteristics.

A flywheel assembly in accordance with a thirtieth aspect of the present invention is the flywheel assembly of the twenty-ningth aspect, wherein the first damper includes the first spring, a first member, and a second member. The first member supports rotating direction ends of the first spring. Further, the second member is rotatable relative to the first member and supports the rotating direction ends of the first spring. The axially extending portions are engaged with the first member in the rotating direction.

According to a thirty-first aspect of the present invention, a flywheel assembly to which torque is transmitted from a crankshaft of an engine includes a flywheel and

a damper mechanism. The damper mechanism elastically connects the flywheel to the crankshaft in a rotating direction. The damper mechanism includes first and second dampers. The first damper has a first spring to realize low rigidity characteristics in a small torsional angle area of torsional characteristics. The second damper has a second spring to realize high rigidity characteristics in a large torsional angle area of the torsional characteristics. The first damper includes the first spring, a second damper, and a torque transmission member. The first member supports rotating direction ends of the first spring. The second member is rotatable relative to the first member and supports the rotating direction ends of the first spring. The torque transmission member is attached to the crankshaft. The torque transmission member is engaged with the first member in the rotating direction and attachable to and detachable from the first member in the axial direction.

In this flywheel assembly, when the crankshaft rotates, torque is transmitted from the torque transmission member to the damper mechanism, and further to the flywheel. In the damper mechanism, torque is transmitted through the first spring and the second spring. When torque variations due to combustion fluctuations of the engine are inputted to the flywheel assembly, the first spring and the second spring are compressed in the damper mechanism to absorb and attenuate torsional vibrations. In this flywheel assembly, it easy to assemble and disassemble the first damper and the torque transmission member because the torque transmission member is attachable to and detachable from the first member of the first damper in the axial direction.

A flywheel assembly in accordance with a thirty-second aspect of the present invention is the flywheel assembly of the thirty-first aspect, wherein the first member is formed with a first axially penetrating hole, and the torque transmission member extends through the first axially penetrating hole. In this flywheel assembly, the

torque transmission member can directly transmit torque to the first member. Further, the torque transmission member can be attached to and detached from the first member in the axial direction.

A flywheel assembly in accordance with a thirty-third aspect of the present invention is the flywheel assembly of the thirty-second aspect, wherein the second member is formed with a second axially penetrating hole corresponding to the first axially penetrating hole. Further, the second axially penetrating hole is longer in the rotating direction than the first axially penetrating hole and the torque transmission member. The torque transmission member extends through the second axially penetrating hole in the axial direction. In this flywheel assembly, the torque transmission member can move in the second axially penetrating hole in the rotating direction.

A flywheel assembly in accordance with a thirty-fourth aspect of the present invention is the flywheel assembly of the thirty-third aspect, wherein the second member has a block shape, and the first member is a plate having at least a portion located on one of axial sides of the second member. In this flywheel assembly, the structure of the first member and the second member is very simple.

A flywheel assembly in accordance with a thirty-fifth aspect of the present invention is the flywheel assembly of any one of the thirty-first to thirty-fourth aspects, wherein the first spring is held by the first member and the second member such that the first spring is not separated from the first member and the second member.

A flywheel assembly in accordance with a thirty-sixth aspect of the present invention is the flywheel assembly of the thirty-fifth aspect, wherein the second member is formed with a first concave portion to accommodate the first spring.

A flywheel assembly in accordance with a thirty-seventh aspect of the present invention is the flywheel assembly of the thirty-sixth aspect, wherein the first member has a wall portion to cover the first concave portion.

A flywheel assembly in accordance with a thirty-eighth aspect of the present invention is the flywheel assembly of the thirty-seventh aspect, wherein the second member is formed with a pair of second concave portions extending in the rotating direction from rotating direction ends of the first concave portion. Further, the second concave portion has a width shorter than that of the first concave portion. Moreover, the first member has a pair of claw portions abutting the rotating direction end of the first spring and movable within the first and second concave portions in the rotating direction.

According to a thirty-ninth aspect of the present invention, a flywheel assembly to which torque is transmitted from a crankshaft of an engine includes a flywheel and a damper mechanism. A clutch device is installed to the flywheel. The damper mechanism elastically connects the flywheel to the crankshaft in a rotating direction. The flywheel holds the damper mechanism such that the damper mechanism cannot be detached from the flywheel.

In this flywheel assembly, when the crankshaft rotates, torque is transmitted to the flywheel through the damper mechanism. When torque variation due to combustion fluctuation of the engine is inputted to the flywheel assembly, the first spring and the second spring are compressed in the damper mechanism to absorb and attenuate torsional vibrations. In this flywheel assembly, it is easy to manage and transport the flywheel assembly because the damper mechanism is tightly held by the flywheel.

A flywheel assembly in accordance with a fortieth aspect of the present invention is the flywheel assembly of the thirty-ninth aspect, wherein the damper mechanism includes a first damper and a second damper. The first damper has a first spring to realize low rigidity characteristics in a small torsional angle area of torsional characteristics. Further, the second damper has a second spring to realize high rigidity characteristics in a large torsional angle area of the torsional characteristics. The flywheel holds the first damper the second damper such that the first and second damper can not be detached from the flywheel. In this flywheel assembly, it is easy to manage and transport the flywheel assembly, since the first damper and the second damper are tightly held by the flywheel.

A flywheel assembly in accordance with a forty-first aspect of the present invention is the flywheel assembly of the thirty-ninth or fortieth aspects, wherein the flywheel has a flywheel main body formed with a friction surface with which the clutch device is engaged, and a disk-like plate fixed to the flywheel main body. The disk-like plate holds the damper mechanism. In this flywheel assembly, a simple structure is realized because the disk-like plate is a member separate from the flywheel main body.

A flywheel assembly in accordance with a forty-second aspect of the present invention is the flywheel assembly of the fortieth aspect, wherein the flywheel has a flywheel main body formed with a friction surface with which the clutch device is engaged, and first and second disk-like plates fixed to the flywheel main body. The first disk-like plate supports an axial transmission side of the second spring, and the second disk-like plate is fixed to the first disk-like plate and supports an axial engine side of the second spring. In this flywheel assembly, a simple structure is realized

because the first and second disk-like plates are members separate from the flywheel main body.

A flywheel assembly in accordance with a forty-third aspect of the present invention is the flywheel assembly of the forty-second aspect, wherein the first disk-like plate supports an axially transmission side of the first damper, and the second disk-like plate is fixed to the first disk-like plate and supports an axial engine side of the first damper. In this flywheel assembly, the number of the components is smaller than in conventional assemblies because the second disk-like plate supports the axial engine side of the first damper as well as the axial engine side of the second spring.

A flywheel assembly in accordance with a forty-fourth aspect of the present invention is the flywheel assembly of any one of the fortieth, forty-second aspect, or forty-third aspects, wherein the flywheel assembly further includes a torque transmission member attached to the crankshaft and engaged with the damper mechanism such that the torque transmission member can be attached to an detached from the damper mechanism in the axial direction. In this flywheel assembly, a small number of components are used because the second disk-like plate supports the axial engine side of the first damper as well as that of the second spring.

A flywheel assembly in accordance with a forty-fifth aspect of the present invention is the flywheel assembly of the forty-fourth aspect, wherein the torque transmission member is engaged with the damper mechanism such that the torque transmission member inputs torque to the first spring of the first damper. In this flywheel assembly, it is easy to assemble the flywheel assembly to the crankshaft because the torque transmission member is engaged with the damper mechanism such that the toque transmission member is attachable to and detachable from the damper mechanism.

A flywheel assembly in accordance with a forty-sixth aspect of the present invention is the flywheel assembly of the fortieth, or forty-second to forty-fifth aspects, wherein the flywheel assembly further includes a friction generating mechanism to generate friction when the crankshaft and the flywheel rotate relatively. The flywheel holds the friction generating mechanism such that the friction generating mechanism can not be detached from the flywheel. In this flywheel assembly, it is easy to manage and transport the flywheel assembly because the friction generating mechanism is tightly held by the flywheel.

A flywheel assembly in accordance with a forty-seventh aspect of the present invention is the flywheel assembly of the forty-sixth aspect, wherein the friction generating mechanism is engaged with a transmission side member such that the friction generating mechanism can be attached to and detached from the crankshaft side member. In this flywheel assembly, it is easy to assemble the flywheel assembly to the crankshaft because the friction generating mechanism is engaged with the transmission side member such that the toque transmission member is attachable to and detachable from the damper mechanism.

A flywheel assembly in accordance with a forty-eighth aspect of the present invention is the flywheel assembly of the forty-sixth or forty-seventh aspect, wherein a radial position of the friction generating mechanism is radially outward that of the damper mechanism. The friction generating mechanism is located in the axial direction within an axial area defined by axial edges of the second spring. In this flywheel assembly, the axial length of the flywheel assembly is shorter than those of conventional flywheel assemblies because the damper mechanism and the friction generating mechanism are aligned in the radial direction

According to a forty-ninth aspect of the present invention, a flywheel assembly to which torque is transmitted from a crankshaft of an engine includes a flywheel, a damper mechanism, and a friction generating mechanism. A clutch device is installed to the flywheel. The damper mechanism elastically connects the flywheel to the crankshaft in a rotating direction. The friction generating mechanism generates friction when the crankshaft and the flywheel rotate relatively. The flywheel holds the damper mechanism and the friction generating mechanism such that the damper mechanism and the friction generating mechanism cannot be detached from the flywheel. In this flywheel assembly, when the crankshaft rotates, torque is transmitted to the flywheel through the damper mechanism. When torque variations due to combustion fluctuation of the engine are inputted to the flywheel assembly, the damper mechanism and the friction generating mechanism operate to absorb and attenuate torsional vibrations. It is easy to manage and transport this flywheel assembly because the damper mechanism and the friction generating mechanism are tightly held by the flywheel.

A flywheel assembly in accordance with a fiftieth aspect of the present invention is the flywheel assembly of the forty-ninth aspect, wherein the flywheel assembly further includes a first engagement portion and a second engagement portion. The first engagement portion is fixed to the crankshaft and engaged with the damper mechanism such that the first engagement portion can be attached to and detached from the damper mechanism in the axial direction. The second engagement portion is fixed to the crankshaft and engaged with the friction generating mechanism such that the second engagement portion can be attached to and detached from the friction generating mechanism in the axial direction. This flywheel assembly is easy to assemble with the crankshaft.

These and other objects, features, aspects, and advantages of the present invention will become apparent to those skilled in the art from the following detailed description, which, taken in conjunction with the annexed drawings, discloses a preferred embodiment of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the attached drawings which form a part of this original disclosure:

Fig. 1 is a schematic cross-sectional view of a clutch device in accordance with a preferred embodiment of the present invention;

Fig. 2 is an alternate schematic cross-sectional view of the clutch device of Fig. 1;

Fig. 3 is an elevational view of the clutch device of Fig. 1;

Fig. 4 is an enlarged fragmentary cross-sectional view that particularly illustrates a frictional resistance generating mechanism of the clutch device of Fig. 1;

Fig. 5 is an enlarged fragmentary elevational view that particularly illustrates the frictional resistance generating mechanism of the clutch device of Fig. 1;

Fig. 6 is an elevational view of a first flywheel of the clutch device of Fig. 1;

Fig. 7 is an elevational view of a support plate for the first flywheel;

Fig. 8 is a cross-sectional view of the support plate taken along line segments and arc labelled VIII - VIII in Fig. 7;

Fig. 9 is an elevational view of a disk-like member of the clutch device of Fig. 1;

Fig. 10 is a cross-sectional view of the disk-like member taken along angle X - X in Fig. 9;

Fig. 11 is a fragmentary plan view of the disk-like member viewed in a direction along ray XI in Figs. 9 and 10;

Fig. 12 is a fragmentary elevational view of a second friction plate of the clutch device of Fig. 1;

Fig. 13 is a cross-sectional view of the second friction plate taken along line XIII - XIII in Fig. 12;

Fig. 14 is a view of a mechanical circuit diagram of a damper mechanism of the clutch device of Fig. 1;

Fig. 15 is a view of a graph that illustrates torsion characteristics of the damper mechanism;

Fig. 16 is a cross-sectional view of a spring rotational supporting mechanism of the damper mechanism;

Fig. 17 is an elevational view of the spring rotational supporting mechanism;

Fig. 18 is an elevational view of a block of the spring rotational supporting mechanism;

Fig. 19 is a vertical cross-sectional view of the block;

Fig. 20 is a top plan view of the block;

Fig. 21 is an alternate cross-sectional view of the block;

Fig. 22 is an elevational view of a plate of the spring rotational supporting mechanism;

Fig. 23 is a vertical cross-sectional view of the plate;

Fig. 24 is a plan view of the plate;

Fig. 25 is a vertical cross-sectional view of a low rigidity damper of the spring rotational supporting mechanism;

Fig. 26 is a top plan view of the low rigidity damper;

Fig. 27 is a front view of a spring seat of the spring rotational supporting mechanism;

Fig. 28 is a vertical cross-sectional view of the spring seat;

Fig. 29 is a rear view of the spring seat;

Fig. 30 is a vertical cross-sectional view of the spring seat; and

Fig. 31 is vertical cross-sectional view of a first flywheel assembly and a second flywheel assembly of the clutch device in which the flywheel assemblies are separated in the axial direction.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Selected embodiments of the present invention will now be explained with reference to the drawings. It will be apparent to those skilled in the art from this disclosure that the following description of the embodiments of the present invention is provided for illustration only, and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

(1) Structure

Referring initially to Figs. 1 and 2, a clutch device 1 in accordance with a preferred embodiment of the present invention is primarily formed of a first flywheel assembly 4, a second flywheel assembly 5, a clutch cover assembly 8, a clutch disk assembly 9, and a release device 10. The first and second flywheel assemblies 4 and 5 are combined to form a flywheel damper 11 including a damper mechanism 6.

An engine (not shown) is arranged on the left side in Figs. 1 and 2, and a transmission (not shown) is arranged on the right side. The clutch device 1 is a device that releasably transmits a torque between a crankshaft 2 on the engine side and an input shaft 3 on the transmission side.

The first flywheel assembly 4 is fixed to an end of the crankshaft 2. The first flywheel assembly 4 is a member that ensures a large moment of inertia on the crankshaft side. The first flywheel assembly 4 is primarily formed of a disk-like member 13, an annular member 14, and a support plate 39, which will be described later. The disk-like member 13 has a radially inner end fixed to an end of the crankshaft 2 by a plurality of bolts 15. The disk-like member 13 has bolt insertion apertures 13a in locations respectively corresponding to the bolts 15. Each bolt 15 is preferably axially attached to the crankshaft 2 from the transmission side. The annular member 14 is preferably axially fixed to the radially outer end of the disk-like member 13, and has a relatively thick block-like form. The annular member 14 preferably extends toward the transmission side relative to the disk-like member 13. Portions of the annular member 14, however, preferably contact the radially outer end of the disk-like member 13 at a radially outermost portion and a radially outer engine side portion. The radially outer end of the disk-like member 13 is preferably welded to the annular member 14. Further, a ring gear 17 for an engine starter is fixed to an outer peripheral surface of the annular member 14. The first flywheel assembly 4 may be formed of an integral or unitary member.

A structure of the radially outer portion of the disk-like member 13 will now be described in greater detail. As shown in Fig. 4, a radially outer portion of the disk-like member 13 has a flat form, and a friction member 19 is affixed to its surface on the transmission side in the axial direction. As shown in Fig. 6, the

friction member 19 is formed of a plurality of arc-shaped members, and has an annular form as a whole. The friction member 19 functions to dampen shock when the first and second flywheel assemblies 4 and 5 are coupled together. The friction member 19 also serves to stop the relative rotation early in the coupling operation. Alternatively, the friction member 19 may be fixed to a disk-like plate 22.

As shown in Figs. 9-11, the disk-like member 13 is provided at its outer periphery with a cylindrical portion 20 extending axially toward the transmission. The cylindrical portion 20 is supported on the inner peripheral surface of the annular member 14, and is provided at its end with a plurality of recesses 20a. Each recess 20a has a predetermined angular length in the rotating direction, and functions as a part of a rotating-direction engaging portion 69 as described later. Each recess 20a is defined in the rotating direction between the opposite portions, which can be considered as axial claws 20b of the cylindrical portion 20.

Referring again to Figs. 1 and 2, the second flywheel assembly 5 is primarily formed of a flywheel 21 with a friction surface, and the disk-like plate 22. The flywheel 21 with the friction surface has an annular and disk-like form, and is axially located on the transmission side with respect to the outer peripheral portion of the first flywheel assembly 4. The flywheel 21 with the friction surface is provided on its transmission side with a first friction surface 21a. The first friction surface 21a is an annular and flat surface, and can be coupled to the clutch disk assembly 9, which will be described later. The flywheel 21 with the friction surface is further provided on its engine side with a second friction surface 21b. The second friction surface 21b is an annular and flat surface, and functions as a frictional sliding surface of a frictional resistance generating mechanism 7, which will be described later. When compared to the first friction surface 21a, the second

friction surface 21b preferably has a slightly smaller outer diameter and a significantly larger inner diameter. Accordingly, the second friction surface 21b has a larger effective radius than the first friction surface 21a. The second friction surface 21b is axially opposed to the friction member 19.

Description will now be given on the disk-like plate 22. The disk-like plate 22 is arranged axially between the first flywheel assembly 4 and the flywheel 21 having the friction surface. The disk-like plate 22 has a radially outer portion fixed to a radially outer portion of the flywheel 21 having the friction surface by a plurality of rivets 23, and functions as a member rotating together with the flywheel 21 having the friction surface. More specifically, the disk-like plate 22 is formed of a radially outer fixing portion 25, a cylindrical portion 26, a contact portion 27, a coupling portion 28, a spring support portion 29, a radially inner portion 30, and a radially inner cylindrical portion 31, which are aligned radially in this order. The radially outer fixing portion 25 is flat and is in axial contact with the engine side of the radially outer portion of the flywheel 21 having the friction surface. The radially outer fixing portion 25 is fixed to the flywheel 21 by the rivets 23 already described. The cylindrical portion 26 extends axially toward the engine from the inner periphery of the radially outer fixing portion 25, and is arranged on the radially inner side of the cylindrical portion 20 of the disk-like member 13. The cylindrical portion 26 is provided with a plurality of recesses 26a. As shown in Fig. 5, each recess 26a is formed corresponding to the recess 20a in the cylindrical portion 20, but is angularly long in the rotating direction. In the rotating direction, therefore, the opposite ends of each recess 26a are located outside the opposite ends of the corresponding recess 20a. Referring again to Figs. 1 and 2, the contact portion 27 has a circular and flat form, and corresponds to the friction member 19.

The contact portion 27 is axially opposed to the second friction surface 21b of the flywheel 21 having the friction surface with a space therebetween, and various members of the frictional resistance generating mechanism 7, to be described later, are arranged in this space. The frictional resistance generating mechanism 7 is arranged between the contact portion 27 of the disk-like plate 22 of the second flywheel assembly 5 and the flywheel 21 having the friction surface, so that the space required by the structure can be small. The coupling portion 28 is a flat portion located axially on the transmission side with respect to the contact portion 27, and a spring support plate 35 is fixed thereto as described later. The spring support portion 29 accommodates and supports the coil springs 32 of the damper mechanism 6. Since the disk-like plate 22 having the contact portion 27 also has the spring support portion 29, this structure allows a reduction in the number of parts, and simplifies the structure relative to the prior art.

The radially inner cylindrical portion 31of the disk-like plate 22 is radially supported on a radially inner cylindrical portion 13b of the disk-like member 13, and is rotatable thereto. More specifically, a tubular bush 97 is fixed to a radially inner surface of the radially inner cylindrical portion 31. Further, a radially inner surface of the bush 97 is rotatably supported by a radially outer surface of the radially inner cylindrical portion 13b of the disk-like member 13. As mentioned above, the bush 97 and the radially inner cylindrical portion 13b compose a radial direction location positioning mechanism 96, which determines the radial position of the second flywheel assembly 5 relative to the first flywheel assembly 4. The bush 97 may be made of lubricant material or lubricant may be applied to the surface of the bush 97.

Description will now be given on the damper mechanism 6. The damper mechanism 6 elastically couples the crankshaft 2 to the flywheel 21 having the friction surface in the rotating direction. The damper mechanism 6 is formed of a high rigidity damper 38 including a plurality of coil springs 32, and a friction resistance generating mechanism 7. The damper mechanism 6 further includes a spring rotating-direction support mechanism (low rigidity damper) 37 to realize a low rigidity characteristics in a small torsional torque region. The spring rotating-direction support mechanism 37 and the high rigidity damper 38 are located in series in the rotating direction in a torque transmission system.

Each coil spring 32 is preferably formed of a combination of large and small springs. Each coil spring 32 is accommodated in each of the spring support portions 29, and its radially opposite sides and transmission side in the axial direction are supported by the spring support portion 29. The spring support portion 29 also supports the opposite sides in the rotating direction. The spring support plate 35 is fixed to the coupling portion 28 of the disk-like plate 22 by rivets 36. The spring support plate 35 is an annular member, and is formed with spring support portions 35a to support axially an engine side of the radially outward portion of the springs 32.

As shown in Figs. 2 and 3, the spring rotating-direction support mechanism 37 is arranged circumferentially (i.e., in the rotating direction) between the neighboring coil springs 32, and is movable in the rotating direction while being held axially between the disk-like plate 22 and the spring support plate 35. Each spring rotating-direction support mechanism 37 substantially has a block form, and has an axial through aperture.

Referring again to Figs. 1 and 2, the support plate 39 is fixed to the surface of the radially inner portion of the disk-like member 13 on the transmission side in the axial direction. The support plate 39 is formed of a disk-like portion 39a and a plurality of (four in this embodiment) radial protrusions 39b extending radially outward from the outer periphery of the disk-like portion 39a. Each protrusion 39b is provided at diametrally opposite two positions with circular apertures 39d each defined by a surface that tapers. A bolt 40 is fitted into each circular aperture 39d. The bolt 40 is engaged with a screw aperture 33 in the disk-like member 13 to fix the support plate 39 to the disk-like member 13. The radially inward edge of the disk-like portion 39a is in contact with the radially outer surface of the radially inner cylindrical portion 13b of the disk-like member 13 so that the support plate 39 is centered relative to the disk-like member 13. As shown in Fig. 1, the disk-like portion 39a is provided with a plurality of circular apertures 39c corresponding to the bolt 15 through apertures 13a of the disk-like member 13, into which shanks of the bolts 15 are fitted, respectively. As shown in Fig. 2, each protrusion 39b is formed of a radial extension 39e extending substantially along the disk-like member 13, and an axial extension 39f extending axially toward the transmission from the end of the extension 39e. Referring now to Fig. 16, the axial extension 39f of the protrusion 39b is inserted into apertures 64a, 65a, and 70a in each spring rotating-direction support mechanism 37 from the engine side, and can be engaged therewith. As described above, the spring rotating-direction support mechanism 37 and the support plate 39 function as members on the torque input side of the high rigidity damper 38.

Referring again to Figs. 1 and 2, the support plate 39 functions as a bending direction support mechanism to support elastically the second flywheel assembly 5

relative to the crankshaft 2 in the bending direction. The support plate 39 has a high rigidity in the rotating direction to transmit torque and a low rigidity in the bending direction such that the support plate 39 is flexible in response to bending vibrations from the crankshaft 2. The radial extension 39e is located on the transmission side of the disk-like member 13 defining a small axial gap therebetween so that the protrusion 39b can deform to approach the disk-like member 13 within a small range. Next, the spring rotating-direction support mechanism 37 is engaged with the support plate 39 and located between the coil springs 32 in the rotating direction. The spring rotating-direction support mechanism 37 has at least the following three functions:

1) supporting the coil springs 32 in the rotating direction (explained later)

2) providing a first stage low rigidity damper (explained later)

3) providing a portion to be supported by the support plate 39 (explained before)

Accordingly the spring rotating-direction support mechanism 37 might be called a low rigidity damper or support plate engagement portion.

The spring rotating-direction support mechanism 37 will be described in detail primarily referring to Figs. 16-30. The spring rotating-direction support mechanism 37 is located corresponding to the axial extensions 39f of the support plate 39. With reference to Fig. 3, there are preferably four spring rotating-direction support mechanisms 37 in this embodiment. As seen in Fig. 16, each of the mechanisms 37 is a low rigidity damper itself composed of a plate 61, a block 62, and a spring 63 elastically connecting the plate 61 and block 62 in the rotating direction.

The plate 61 is an input member arranged in the spring rotating-direction support mechanism 37 to which torque is transmitted directly from the support plate 39. The plate 61 is, as shown in Fig. 16, and 22-26, a U-like shape member preferably made of metal, for example. The plate 61 is composed of flat portions 64 and 65 on both axial sides and a connection portion 66 connecting the radially outward edges of the flat portions 64 and 65. The plate 61 is open in the radially inward and rotating directions. The flat portions 64 and 65 respectively are formed with apertures 64a and 65a penetrating in the axial direction and elongated in the rotating direction. The axial extension 39f of the support plate 39 is inserted into the apertures 64a and 65a. As shown in Fig. 17, the rotating direction length of the axial extension 39f is almost the same as that of the apertures 64a and 65a so that the rotating direction ends of the axial extension 39f and the apertures 64a and 65a are in contact or have a small gap therebetween. Further, the radial direction length of the axial extension 39f is almost the same as that of the apertures 64a and 65a so that the radial ends of the axial extension 39f and the apertures 64a and 65a are in contact or have a small gap therebetween. As seen in Fig. 16, the distal end of the axial extension 39f extends beyond the flat portion 65 in the axial direction and is located in the concave portion 67 of the disk-like plate 22. The concave portion 67 is longer in the rotating direction than the axial extension 39f so that the axial extension 39f can move in the rotating direction within the concave portion 67. As shown in Figs. 1 and 2, the disk-like plate 22 is axially supported by the support plate 39because the concave portion 67 and the end of the axial extension 39f face each other in the axial direction.

Referring again to Fig. 16, the plate 61 is supported by the disk-like plate 22 such that the plate 61 cannot move in either of the axial directions. Specifically,

the axial surface on the engine side of the flat portion 64 is supported by the support portion 35b of the support plate 35, and the axial surface on the transmission side of the flat portion 65 is supported by the disk-like plate 22. In this arrangement, the plate 61 can slide against the disk-like plate 22 in the rotating direction. As seen in Figs. 1 and 2, it is easy to manage and to assemble the second flywheel assembly 5because the spring rotating-direction support mechanism 37 is held by the flywheel 21 and the disk-like plate 22. It is easily understood that the spring support plate 35 is an annular member having the spring support portions 35a and the support portions 35b arranged in an alternating way in the rotating direction.

As seen in Figs. 22 and 23, the plate 61 further has a pair of protrusions 68 at both the rotating direction end of the connection portion 66 bent from the axially middle portion toward a radially outward direction. The protrusions 68 are claws that directly contact the spring 63 (later described).

The block 62 is, as shown in Fig. 16-21, disposed within the plate 61, i.e., between the flat portions 64 and 65 and radially inward of the connection portion 66. The block 62 is a block shape member preferably made of resin, for example. The outer size of the block 62 is almost the same with the inner size of the plate 61 so that there is little or no gap therebetween. Accordingly, the block 62 can slide against the plate 61 in the rotating direction within a limited angle. The block 62 has a main body 70 formed with an axially penetrating aperture 70a located corresponding to the apertures 64a and 65a of the plate 61. The aperture 70a has the same radial position and length as the apertures 64a and 65a, but is longer than the apertures 64a and 65a in the rotating direction. Thus, the rotation direction ends of the aperture 70a is positioned rotationally outward of rotating direction

ends of the apertures 64a and 65a. The axial extension 39f extends into the aperture 70a and can move in the rotating direction within the aperture 70a. When the axial extension 39f contacts the rotating direction end of the aperture 70a, relative rotation stops between the input members such as the axial extension 39f and the plate 61, and output member such as the block 62.

The main body 70 of the block 62 is formed with a groove 72 on the radially outward surface. The groove 72 is a space confined or covered by the connection portion 66 of the plate 61. The groove 72 has, as shown in Figs. 20 and 21, a first concave portion 72a and a pair of second concave portions 72b extending in the rotating direction from the first concave portion 72a. The second concave portions 72b has the depth in the radial direction that is the same as that of the first concave portion 72a, but is shorter than the first concave portion 72a in the axial direction. Accordingly, end surfaces 72c as stepped surfaces are formed at the rotating direction ends of the first concave portions 72a. The second concave portions 72b extend from the axially middle portion of the first concave portion 72a. As seen in Fig. 16, a spring 63 is disposed in the first concave portion 72a. The spring 63 is a coil spring having extremely short wire diameter, coil diameter, and axial length relative to the coil spring 32. The spring 63 has an extremely small spring constant compared to that of the coil spring 32. More preferably, the spring 63 has a spring constant that is 1/10 or less of that of coil spring 32. Furthermore, as seen in Figs. 17, 25, and 26, the protrusion 68 of the plate 61 is disposed in the second concave portion 72b, and more specifically the protrusion 68 is disposed near the rotating direction ends of the first concave portion 72a and are in contact with or maintain a small gap with the rotating direction ends of the spring 63. The protrusion 68 can move within not only the second concave portion 72b but also

the first concave portion 72a. Accordingly, the spring 63 can be compressed in the rotating direction between the plate 61 and the block 62, more specifically between the protrusion 68 of the plate 61 and the end surface 72c of the first concave portion 72a of the block 62. In addition, the spring 63 is held between the plate 61 and the block 62, that is, the spring 63 is supported in the rotational, axial, and radial direction by the plate 61 and block 62. More specifically, the spring 63 is accommodated within the confined space defined by the first concave portion 72a and the connection portion 66 of the plate 61.

Spring seats 74 are provided at the rotating direction ends of the block 62 to support the coil spring 32 in the rotating direction. The spring seat 74 is, as shown in Fig. 28-31, a member having a substantially circular shape. As seen in Fig. 17, the spring seat 74 has a front surface 76 that contacts a rotating direction end of the coil spring 32 and a rear surface 77 that contacts the block 62 on the opposite side. The spring seat 74 further has a first protruding portion 78 having a columnar shape extending into and engaging with the coil spring 32 and a second protruding portion 79 having an arc shape to support the radially outward surface of the radially inward portion of the coil spring 32 on the front surface 76. The spring seat 74 further has a concave portion 80 having a substantially rectangular shape with which a part of the block 62 is engaged on the rear surface 77. A convex portion 81 that is formed at each of the rotating direction ends of the block 62 is inserted into the concave portion 80 in the rotating direction. The convex portion 81 can be engaged with and disengaged from the concave portion 80 in the rotating direction and supports the spring seat 74 such that the spring seat 74 cannot move in the radial direction. An arc surface 89, a part of a circle seen in the axial direction, is formed at the axially middle portion of the radially inward side on the

rear surface 77 side of the spring seat 74. As seen in Fig. 28, inclined surfaces 90 are formed on the axial sides of the arc surface 89 and its rotating direction thickness becomes shorter as it extends radially outward.

As seen in Figs. 16 and 17, the rear surface 77 of the spring seat 74, more specifically the radially outward portion of the rear surface 77, is supported by the rotating direction ends of the spring support portion 29 of the disk-like plate 22 in the rotating direction. Collars 92 are provided on the disk-like plate 22 radially inward of the spring rotating-direction support mechanism 37. Further, each collar 92 is fixed to the disk-like plate 22 by a rivet 91. The collars 92 axially extend from the disk-like plate 22 and are in contact with the arc surface 89 of the spring seat 74. The collar 92 can be engaged with and disengaged from the arc surface 89 of the spring seat 74 in the rotating direction. The above-mentioned engagement of the collar 92 and the spring seat 74 makes it possible to transmit torque between them. Consequently, by transmitting torque from the collar 92 to the disk-like plate 22, it is possible to support the radially inward portion of the spring seat 74 even if the drawing of the spring support portion 29 of the disk-like plate 22 is not extremely deep.

Since the spring rotating-direction support mechanisms 37 are disposed between the coil springs 32 in the rotating direction, it is possible to decrease the diameter of the damper mechanism 6, especially because the springs 63 are located completely within an annular area defined by a radially inner edge and a radially outer edge of the coil springs 32.

Referring to Figs. 1 and 2, the function of the support plate 39 is at least as follows:

1) supporting the second flywheel assembly 5 on the crankshaft 2 in the axial direction;

2) supporting the second flywheel assembly 5 on the crankshaft 2 in the radial direction;

3) supporting the second flywheel assembly 5 such that the second flywheel assembly 5 can move relative to the crankshaft 2 in the bending direction; and

4) transmitting torque from the crankshaft 2 to the second flywheel assembly 5

Since the support plate 39 is designed to handle a multitude of functions, some of which are mentioned above, individual components for each function are not needed, thus the number of the components is less than in conventional assemblies. Since the support plate 39 is a simple member on the whole, the overall structure of the flywheel is further simplified. Furthermore, since the axial extensions 39f of the support plate 39 is engaged with the spring rotating-direction support mechanism 37 of the damper mechanism 6 such that the spring rotating-direction support mechanism 37 is attachable to and detachable from the axial extensions 39f, it is easy to assemble the second flywheel assembly 5 to the crankshaft 2 and disassemble the second flywheel assembly 5 from the crankshaft 2.

Still referring to Figs. 1 and 2, the frictional resistance generating mechanism 7 operates in a rotating direction space between the crankshaft 2 and the flywheel 21 having the friction surface. Further, the frictional resistance generating mechanism 7 functions in parallel with the coil spring 32 to generate a predetermined hysteresis torque when relative rotation occurs between the crankshaft 2 and the flywheel 21 with the friction surface. The frictional resistance generating mechanism 7 is formed of a plurality of washers, which are arranged

between the second friction surface 21b of the flywheel 21 having the friction surface and the contact portion 27 of the disk-like plate 22, and are in contact with each other. As seen in Fig. 4, the frictional resistance generating mechanism 7 has a first friction washer 41, a first friction plate 42, a conical spring 43, a second friction plate 44, and a second friction washer 45, which are axially aligned in this order from the position near the contact portion 27 toward the flywheel 21 with the friction surface. The first and second friction washers 41 and 45 are preferably made of a material having a high friction coefficient, and other members are preferably made of steel. As described above, the disk-like plate 22 has a function of holding the frictional resistance generating mechanism 7 on the side of the flywheel 21 with the friction surface. This arrangement reduces the number of parts, and simplifies the structure.

The first friction washer 41 is located between the contact portion 27 and the first friction plate 42. In this embodiment, the first friction washer 41 is fixed to the first friction plate 42. Alternatively, it may be fixed to the contact portion 27, or may be fixed to neither of them. The first friction plate 42 is located between the first friction washer 41 and the conical spring 43. The first friction plate 42 is provided at its outer periphery with a plurality of protrusions 42a extending axially toward the transmission. A radially inner surface of the end of each protrusion 42a is preferably in contact with the outer peripheral surface of the flywheel 21 having the friction surface, and is radially supported thereby. The conical spring 43 has a conical form when it is not compressed. In Fig. 4, the conical spring 43 is compressed between the first and second friction plates 42 and 44 into a flat form so that it applies an elastic force to the members on the opposite sides. The second friction plate 44 is located between the conical spring 43 and the second friction

washer 45. The second friction plate 44 is provided at its inner periphery with an inner cylindrical portion 44a extending axially toward the engine. The inner peripheral surface of the radially inner cylindrical portion 44a is radially supported by the disk-like plate 22. The outer peripheral surface of the inner cylindrical portion 44a is in contact with the inner peripheral surfaces of the first friction plate 42 and the conical spring 43 to support them radially. The second friction plate 44 is provided at its outer periphery with recesses 44e, through which the foregoing protrusions 42a extend for engagement, respectively. Owing to this engagement, the first friction plate 42 is axially movable but rotationally unmovable with respect to the second friction plate 44. The second friction washer 45 is located between the second friction plate 44 and the second friction surface 21b of the flywheel 21 having the friction surface. In this embodiment, the second friction washer 45 is fixed to the second friction plate 44. However, it may be fixed to the flywheel 21 having the friction surface, or may be fixed to neither of them.

The second friction plate 44 is provided at its outer periphery with a plurality of protrusions 44b. The protrusions 44b are formed corresponding to the recesses 26a, respectively, and each are formed of a protruding portion 44c extending radially outward and a claw 44d extending axially toward the engine from the end of the protruding portion 44c. The protruding portion 44c extends radially through the recess 26a. The claw 44d is located radially outside the cylindrical portion 26, and extends axially into the recess 20a in the cylindrical portion 20 of the disk-like member 13 from the transmission side. The claw 44d and the recess 20a form a rotating-direction engaging portion 69 located between the disk-like member 13 and the second friction plate 44.

As seen in Fig. 5, in the rotating-direction engaging portion, the claw 44d has a circumferential width (i.e., width in the rotating direction) smaller than that of the recess 20a, and therefore can move a predetermined angle within the recess 20a. This means that the second friction plate 44 is movable through a predetermined angular range with respect to the disk-like member 13. This predetermined angle corresponds to minute torsional vibrations caused by variations in engine combustion, and has magnitudes to absorb effectively such vibrations without causing a high hysteresis torque. More specifically, a circumferential gap 46 of a torsion angle θ1 is maintained in the rotating direction R1 with respect to the claw 44d, and a rotating direction space 47 of a torsion angle θ2 is maintained in the rotating direction R2. Consequently, a total of the torsion angles θ1 and θ2 is equal to the predetermined angle, which is the angle the second friction plate 44 can rotate relatively to the disk-like member 13. As seen in Fig. 15, in this embodiment, the total torsion angle is preferably equal to 8 degrees, and is preferably in a range slightly exceeding the damper operation angle, which is produced by minute torsional vibrations due to the variations in engine combustion.

From another viewpoint, with reference to Fig. 11, the minute circumferential spaces 46 and 47 may be considered to be formed by the claw 20b of the disk-like member 13 and the claw 44d of the second friction plate 44. Each of the claws 20b and 44d is formed by axially bending a radially outer portion of the disk-like member 13 and the second friction plate 44. Thus, each of the claws 20b and 44d has a simple structure.

The minute circumferential spaces 46 and 47, which are formed by the recesses 20a in the disk-like member 13 and the claws 44d of the second friction plate 44 as described above, can be provided merely by locating the first and

second flywheel assemblies 4 and 5 close to each other in the rotating direction, and fitting the claws 44d into the recesses 20a, respectively. This facilitates the assembling operation.

Since the minute circumferential spaces 46 and 47 formed by the recesses 20a in the disk-like member 13 and the claws 44d of the second friction plate 44 are formed between the radially outer portions of the first and second flywheel assemblies 4 and 5, the radially inner portion of each of the flywheel assemblies 4 and 5 can be designed with high flexibility.

As seen in Figs. 1 and 2, the radial position of the frictional resistance generating mechanism 7 is radially outward that of the damper mechanism 6, and the frictional resistance generating mechanism 7 is located within an axial space defined by the axial edges of the coil springs 32. As explained above, the damper mechanism 6 and the frictional resistance generating mechanism 7 are aligned in the radial direction, i.e., the radial positions are different and the axial positions are substantially the same, so that the axial length of the flywheel damper 11 is smaller than those of conventional dampers.

The clutch cover assembly 8 elastically biases a friction facing 54 of the clutch disk assembly 9 toward the first friction surface 21a of the flywheel 21 having the friction surface. The clutch cover assembly 8 is primarily formed of a clutch cover 48, a pressure plate 49, and a diaphragm spring 50.

The clutch cover 48 is a disk-like member preferably made of sheet metal, and has a radially outer portion fixed to the flywheel 21 having the friction surface by bolts 51.

The pressure plate 49 is preferably made of, e.g., cast iron. The pressure plate 49 is arranged radially inside the clutch cover 48, and is axially located on the

transmission side with respect to the flywheel 21 having the friction surface. The pressure plate 49 has a pressing surface 49a opposed to the first friction surface 21a of the flywheel 21 having the friction surface. The pressure plate 49 is provided on its surface remote from the pressing surface 49a with a plurality of arc-shaped protruding portions 49b protruding toward the transmission. The pressure plate 49 is unrotatably coupled to the clutch cover 48 with a plurality of arc-shaped strap plates 53 allowing axial movement. In the clutch engaged state, the strap plates 53 applies a load to the pressure plate 49 to move it away from the flywheel 21 having the friction surface.

The diaphragm spring 50 is preferably a disk-like member arranged between the pressure plate 49 and the clutch cover 48, and is formed of an annular elastic portion 50a and a plurality of lever portions 50b extending radially inward from the elastic portion 50a. The elastic portion 50a is in axial contact with the transmission side of the protruding portion 49b of the pressure plate 49.

The clutch cover 48 is provided at its inner periphery with a plurality of tabs 48a, which extend axially toward the engine, and then are bent radially outward. Each tab 48a extends toward the pressure plate 49 through an aperture in the diaphragm spring 50. Two wire rings 52 supported by the tabs 48a support the axially opposite sides of the radially inner portion of the elastic portion 50a of the diaphragm spring 50. In this state, the elastic portion 50a is axially compressed to apply an axial elastic force to the pressure plate 49 and the clutch cover 48.

The clutch disk assembly 9 has a friction facing 54 arranged between the first friction surface 21a of the flywheel 21 having the friction surface and the pressing surface 49a of the pressure plate 49. The friction facing 54 is fixed to a

hub 56 via an annular disk-like plate 55. The hub 56 has a central aperture for spline-engagement with the transmission input shaft 3.

The release device 10 is a mechanism for driving the diaphragm spring 50 of the clutch cover assembly 8 to perform the clutch releasing operation on the clutch disk assembly 9. The release device 10 is primarily formed of a release bearing 58 and a hydraulic cylinder device (not shown). The release bearing 58 is primarily formed of inner and outer races as well as a plurality of rolling elements arranged therebetween. The release bearing 58 can bear radial and thrust loads. A cylindrical retainer 59 is attached to an outer race of release bearing 58. The retainer 59 has a cylindrical portion in contact with the outer peripheral surface of the outer race, a first flange, which extends radially inward from an axial end on the engine side of the cylindrical portion and is in contact with the surface of the engine side of the outer race, and a second flange extending radially outward from an end on the transmission side of the cylindrical portion. The second flange is provided with an annular support portion, which is in axial contact with a portion on the transmission side of the radially inner end of each lever portion 50b of the diaphragm spring 50.

A hydraulic cylinder device is primarily formed of a hydraulic chamber forming member and a piston 60. The hydraulic forming member and the cylindrical piston 60 arranged radially inside the member define a hydraulic chamber between them. The hydraulic chamber can be supplied with a hydraulic pressure from a hydraulic circuit. The piston 60 has a substantially cylindrical form, and has a flange, which is in axial contact with the inner race of the release bearing 58 from the transmission side. When the hydraulic circuit supplies

hydraulic fluid into the hydraulic chamber, the piston 60 axially moves the release bearing 58 toward the engine.

As already described, each of the first and second flywheel assemblies 4 and 5 provides an assembly independent of the other, and is axially removably attached. More specifically, the first and second flywheel assemblies 4 and 5 are engaged with each other owing to engagement between the cylindrical portion 20 and the second friction plate 44, engagement between the disk-like member 13 and the contact portion 27, engagement between the spring support plate 35 and the spring rotating-direction support mechanism 37, and engagement between the radially inner cylindrical portion 13b and the radially inner cylindrical portion 31, which are provided at positions located radially inward in this order, respectively. These assemblies 4 and 5 are axially movable through a predetermined range with respect to each other. More specifically, the second flywheel assembly 5 is axially movable with respect to the first flywheel assembly 4 between a position, where the contact portion 27 is slightly spaced from the friction member 19, and a position, where the contact portion 27 is in contact with the friction member 19.

(2) Operation

(2-1) Torque transmission

In this clutch device 1, a torque is supplied from the crankshaft 2 of the engine to the flywheel damper 11, and is transmitted from the first flywheel assembly 4 to the second flywheel assembly 5 via the damper mechanism 6. In the damper mechanism 6, the torque is transmitted through the support plate 39, the spring rotating-direction support mechanism 37, the high rigidity damper 38 and the disk-like plate 22 in this order. As shown in Fig. 16, in the spring rotating-direction support mechanism 37, torque is transmitted through the plate 61, the

spring 63 and the block 62 in this order. As shown in Figs. 3, 16, and 17, in the high rigidity damper 38, torque is transmitted through the spring seat 74, the coil spring 32, and the spring seat 74. Torque is transmitted from the high rigidity damper 38 to the disk-like plate 22 via the collars 92 and the rivets 91. Referring again to Figs. 1 and 2, further, the torque is transmitted from the flywheel damper 11 to the clutch disk assembly 9 in the clutch engaged state, and is finally provided to the input shaft 3.

As seen in Fig. 14, when the clutch device 1 receives combustion variations from the engine, the spring rotating-direction support mechanism 37 and the high rigidity damper 38 operate in the damper mechanism 6. As seen in Fig. 17, in the spring rotating-direction support mechanism 37, the plate 61 and the block 62 rotate relatively to compress the spring 63. Referring again to Fig. 14, in the high rigidity damper 38, the support plate 39 and the spring rotating-direction support mechanism 37 rotate relative to the disk-like plate 22 to compress the plurality of coil springs 32 in the rotating direction. Further, the frictional resistance generating mechanism 7 generates a predetermined hysteresis torque. Through the foregoing operations, the torsional vibrations are absorbed and damped.

More specifically, as seen in Fig. 3, each coil spring 32 is compressed between the spring rotating-direction support mechanism 37 and a circumferential end of the spring support portion 29 of the disk-like plate 22. As seen in Figs. 4 and 5, in the frictional resistance generating mechanism 7, the first and second friction plates 42 and 44 rotate together with the disk-like member 13, and rotate relatively to the disk-like plate 22 and the flywheel 21 having the friction surface. Consequently, the first friction washer 41 slides between the contact portion 27 and the first friction plate 42, and the second friction washer 45 slides between the

second friction plate 44 and the flywheel 21 having the friction surface. Since two friction surfaces reliably operate, a relatively large hysteresis torque occurs. In the above structure, the second friction surface 21b of the flywheel 21 having the friction surface provides the friction surface of the frictional resistance generating mechanism 7. This reduces the number of parts, and simplifies the structure relative to the prior art.

When the minute torsional vibrations caused by the variations in combustion of the engine are supplied to the clutch device 1, the damper mechanism 6 operates in a manner, which will now be described with reference to a mechanical circuit diagram of Fig. 14 and a torsion characteristic diagram of Fig. 15. When minute torsional vibrations are supplied to the clutch device 1, in which the coil springs 32 of the damper mechanism 6 are in the compressed state, the second friction plate 44 of the frictional resistance generating mechanism 7 rotates relatively to the disk-like member 13 through a range corresponding to the minute circumferential space 46 and 47 between the edge of the recess 20a in the cylindrical portion 20 of the disk-like member 13 and the claw 44d. Thus, the first and second friction plates 42 and 44 rotate together with the contact portion 27 and the flywheel 21 having the friction surface as well as the first and second friction washers 41 and 45 interposed therebetween. Consequently, the minute torsional vibrations do not cause a high hysteresis torque. More specifically, at "AC2 HYS" in the torsion characteristic diagram of Fig. 15, the coil spring 32 operates, but the frictional resistance generating mechanism 7 does not cause the sliding. Thus, in the predetermined torsion angle range, a hysteresis torque much smaller than the ordinary hysteresis torque is produced. This small hysteresis torque is preferably about 1/10 of the hysteresis torque in the whole range. Since the structure includes

the minute circumferential-direction space 46 and 47, which prevents operation of the frictional resistance generating mechanism 7 within the predetermined angular range in the torsion angle characteristics, the vibration and noise levels can be significantly reduced.

(2-2) Clutch Engaging and Releasing Operations

Referring now to Figs. 1 and 2, when the hydraulic circuit (not shown) supplies the hydraulic fluid into the hydraulic chamber of the hydraulic cylinder, the piston 60 moves axially toward the engine. Thereby, the release bearing 58 axially moves the radially inner end of the diaphragm spring 50 toward the engine. Consequently, the elastic portion 50a of the diaphragm spring 50 is spaced from the pressure plate 49. Thereby, the pressure plate 49 biased by the strap plates 53 moves away from the friction facing 54 of the clutch disk assembly 9 so that the clutch is released.

In the clutch release operation, the release bearing 58 applies an axial load directed toward the engine to the clutch cover assembly 8, and this load axially biases and moves the second flywheel assembly 5 toward the engine. Thereby, the contact portion 27 of the disk-like plate 22 in the relative rotation suppressing mechanism 24 is pressed against the friction member 19 to engage frictionally the disk-like member 13. Thus, the second flywheel assembly 5 becomes unrotatable with respect to the first flywheel assembly 4. In other words, the second flywheel assembly 5 is locked with respect to the crankshaft 2 so that the damper mechanism 6 does not operate. Accordingly, when the rotation speed passes through the resonance point in a low speed range (e.g., from 0 to 500 rpm) during starting or stopping the engine, it is possible to suppress the breakage as well as noises and vibrations, which may be caused by the resonance by releasing the clutch.

In this operation, since the damper mechanism 6 is locked by using the load applied from the release device 10 in the clutch releasing operation, the structure can be simple. In particular, since the relative rotation suppressing mechanism 24 is formed of the members with simple structures such as the disk-like member 13 and the disk-like plate 22, a special structure is not required.

Furthermore, in the above-mentioned operation, the second flywheel assembly 5 cannot move relative to the first flywheel assembly 4 in the axial direction and in the bending direction. In other words, the second flywheel assembly 5 is locked with the crankshaft 2 so that the support plate 39 as the bending direction support member does not operate. Accordingly, it suppresses damage or sound and/or vibration of the support plate 39 by resonance. The relative rotation suppressing mechanism 24 functions as a bending direction movement suppression mechanism.

Since the locking of the support plate 39 at the clutch release utilizes a load from the release device 10, a simple structure is realized. The relative rotation suppressing mechanism 24 is composed of members with a simple form such as the disk-like plate member 13 and the disk-like plate 22, thus the clutch device 1 does not need a special structure.

(3) Assembling

As seen in Fig. 31, the flywheel damper 11 is composed of the first flywheel assembly 4 and the second flywheel assembly 5 such that they can be assembled and disassembled by movement in the axial direction. Engagement portions of both assemblies 4 and 5 are the rotating direction engagement portion 69 (the recesses 20a of the cylindrical portion 20 of the disk-like member 13, and the claw portions 44d of the second friction plate 44), the relative rotation suppressing

mechanism 24 (the friction member 19 affixed to the disk-like member 13, and the abutting portion 27 of the disk-like plate 22), the support plate engagement portion 37 (the axial extension 39f of the support plate 39, and the apertures 64a, 65a, and 70a of the spring rotating-direction support mechanism 37), and the rotating direction location determination mechanism 96 (the radially inner cylindrical portion 13b of the disk-like member 13, and the bush 97 fixed to the disk-like plate 22). Every engagement portion can be attached and detached merely by movement of it and its respectively opposing members in the axial direction.

As shown in Fig. 31, the first flywheel assembly 4 and the second flywheel assembly 5 are shown separated in the axial direction. As apparent from the figures, the high rigidity damper 38 (the coil springs 32) and the spring rotating-direction support mechanism 37 (the springs 63) are held by the flywheel 21 and the disk-like plate 22 such that the dampers 37 and 38 cannot be detached from the flywheel 21 and the disk-like plate 22. Accordingly, it is easy to manage and transport the second flywheel assembly 5 as a whole. It also becomes easy to assemble the second flywheel assembly 5 with the first flywheel assembly 4 and disassemble it from the second flywheel assembly 4. Moreover, the frictional resistance generating mechanism 7 is also tightly held by the flywheel 21 and the disk-like plate 22 so that it is easy to manage and transport the second flywheel assembly 5.

In addition, the support plate 39 is engaged with the damper mechanism 6 such that the support plate 39 is attachable to and detachable from the damper mechanism 6, and the cylindrical portion 20 of the disk-like member 13 is engaged with the frictional resistance generating mechanism 7 such that the cylindrical portion 20 is attachable to and detachable from the frictional resistance generating

mechanism 7. As a result, it is easy to assemble the second flywheel assembly 5 to the first flywheel assembly 4 and the crankshaft 2.

(3) Other operations and Effects

The spring rotating-direction support mechanism 37 is located between the coil springs in the rotating direction. Further, the radial position and the radial width of the spring rotating-direction support mechanism 37 are substantially the same with those of the coil springs 32 so that it is not necessary to secure special spaces for the spring rotating-direction support mechanism 37, thereby making the whole structure smaller.

The spring rotating-direction support mechanism 37 has the function of supporting the coil springs 32 in the rotating direction, a first stage low rigidity damper, and a portion to be supported by the support plate 39. As mentioned above, the spring rotating-direction support mechanism 37 has a plurality of functions that are usually conducted by different mechanisms, thus, the number of components is small. Further, the spring rotating-direction support mechanism 37 is only composed of three kinds of components such as the plate 61, the block 62 and the springs 63, thereby reducing the manufacture cost.

The disk-like plate 22 is preferably an integral or unitary disk-like member, and achieves a plurality of structures and functions as described below.

1) The contact portion 27 forms a portion of the relative rotation suppressing mechanism 24.

2) The contact portion 27 holds the frictional resistance generating mechanism 7 on the flywheel 21 having the friction surface, and provides the friction surface of the frictional resistance generating mechanism 7.

3) The spring support portion 29 supports the coil springs 32 in the rotating direction, and supports together with the spring support plate 35 to support the coil springs 32 for preventing disengagement.

4) The radially inner cylindrical portion 31 radially positions the flywheel 21 having the friction surface with respect to the crankshaft 2.

Owing to the combination of the two or more of the foregoing structures, the parts can be reduced in number, and the whole structure can be simplified relative to the prior art.

(4) Other Embodiments

Although the embodiments of the clutch device according to the invention have been described and illustrated, the invention is not restricted to them, and can be variously changed or modified without departing from the scope of the invention.

For example, the clutch cover assembly in the foregoing embodiment is of a push type. However, the invention can be applied to a clutch device including a clutch cover assembly of a pull type.

As used herein, the following directional terms "forward, rearward, above, downward, vertical, horizontal, below, and transverse" as well as any other similar directional terms refer to those directions of a device equipped with the present invention. Accordingly, these terms, as utilized to describe the present invention should be interpreted relative to a device equipped with the present invention.

The terms of degree such as "substantially," "about," and "approximately" as used herein mean a reasonable amount of deviation of the modified term such that the end result is not significantly changed. These terms should be construed as including

a deviation of at least ± 5% of the modified term if this deviation would not negate the meaning of the word it modifies.

This application claims priority to Japanese Patent Application Nos. 2003-119042, 2003-119043, and 2003-119044. The entire disclosures of Japanese Patent Application Nos. 2003-119042, 2003-119043, and 2003-119044 are hereby incorporated herein by reference.

While only selected embodiments have been chosen to illustrate the present invention, it will be apparent to those skilled in the art from this disclosure that various changes and modifications can be made herein without departing from the scope of the invention as defined in the appended claims. Furthermore, the foregoing description of the embodiments according to the present invention are provided for illustration only, and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.